Center Innovation Fund: SSC CIF

An Intelligent Strain Gauge with Debond Detection and Temperature Compensation

Completed Technology Project (2012 - 2012)

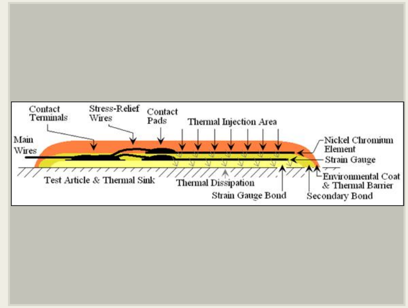
Project Introduction

The harsh rocket propulsion test environment exposes any inadequacy associated with preexisting instrumentation technologies, can critically affect the collection of reliable test data, and justifies investigating any encountered data anomalies. Novel concepts for improved system assessments are often conceived during the high scrutiny investigations by individuals with an in-depth knowledge from maintaining critical test operations. The intelligent strain gauge concept developed for this project was conceived while performing these kinds of activities. Ordinary gauges are designed to provide test article data but they lack the ability to supply information concerning the gauge itself. Changes to the gauge bond integrity are observable in the thermal dissipation rate. A gauge is considered to be a "smart gauge" when it provides supplementary data relating Instrument attributes for performing diagnostic function or producing enhanced data. Accordingly, a gauge with the ability to temporarily self-heat and monitor the rate at which the thermal dissipation occurs can indicate a gauge debond. This project developed novel strain gauge designs that enabled the detection of gauge debonding, and provided for temperature compensation of strain measurements. The improvement to the gauge increased instrument functionality and data collection capability. Two types of fully functional smart strain gauges capable of performing reliable and sensitive debond detection were successfully produced.

To improve instruments functionality in a harsh rocket propulsion test environment, this project developed an intelligent strain gauge. The initial design for this project was a novel foil strain gauge with the capability to measure strain and temperature (Type 1). The novel foil strain gauge pattern features the integration of a silicon-diode temperature sensor and a self-heating element. The silicon-diode sensor provides the gauge temperature for performing real-time temperature compensation algorithms. The silicon-diode temperature sensor was used in the initial gauge pattern due to its enhanced abilities, but after refinement, resistive temperature element was then embedded into a second gauge pattern (Type 2). Then, the debond detection function was tested by monitoring the temperature of the gauge while the gauge was heated and cooled. The temperature signature (rate of heating/cooling) from the gauge was analyzed for both bonded and debonded gauges. Finally, a small control circuit was created with the capability to self-execute a bond integrity check, and perform real-time temperature compensation was also added. By combining the control circuit with the special gauge the smart gauge was converted into a fully functioning intelligent sensor system.

Anticipated Benefits

Benefits to NASA funded missions include providing an economical source of strain gauge for future applications throughout NASA.



Type 2 Smart Strain Gauge

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Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Stennis Space Center (SSC)

Responsible Program:

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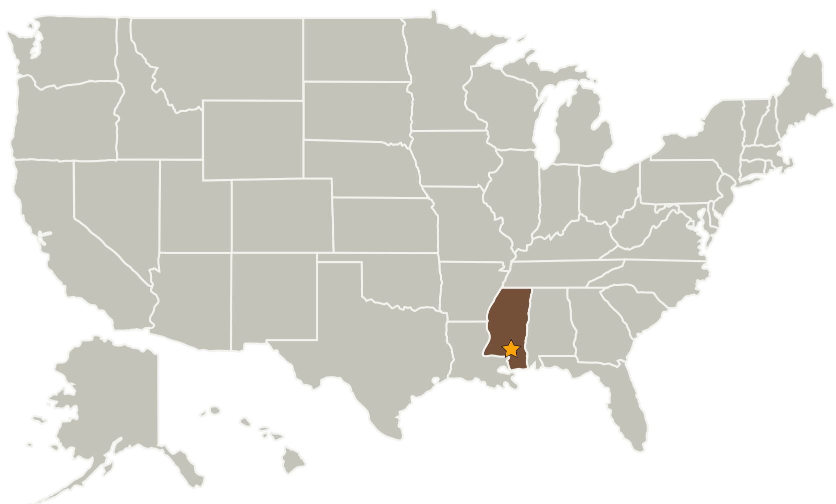
The intelligent system is an economically viable method for feasibly employing strain instrumentation throughout NASA. It is highly applicable and more useful to implement, because of the additional data provided, and can be installed/utilized with the same level of effort as existing strain instrumentation systems; it could be directly integrated into preexisting Stennis Space Center Ground Propulsion Test Facilities with minimal additional cost, and could be added without any level of effort.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Stennis Space Center(SSC)	Lead Organization	NASA Center	Stennis Space Center, Mississippi

Primary U.S. Work Locations
Mississippi

Project Management

Program Director:
Michael R Lapointe

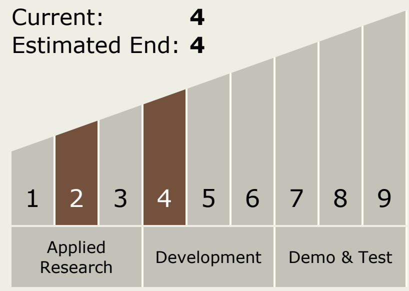
Program Manager:
Ramona E Travis

Project Manager:
Scott L Jensen

Principal Investigator:
Scott L Jensen

Technology Maturity (TRL)

Start: **2**
Current: **4**
Estimated End: **4**

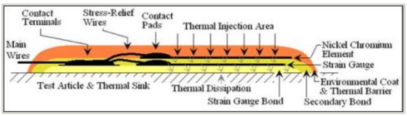


Technology Areas

Primary:

- TX09 Entry, Descent, and Landing
  └ TX09.4 Vehicle Systems
    └ TX09.4.6 Instrumentation and Health Monitoring for EDL

Images



Type 2 Smart Strain Gauge
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(https://techport.nasa.gov/image/3324)